Agronomic biofortification improves grain zinc nutritional quality of maize grown under contrasting soil types in Malawi

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Background and significance of the study

- Zinc (Zn) is an essential micronutrient that performs important physiological and biochemical functions in biological systems
- Recent estimates show that nearly 1 billion people worldwide suffer from Zn malnutrition
- In Malawi, Zn deficiency in humans is widespread with an estimated prevalence rate of 62% due to low dietary diversity and high dependence on maize (*Zea mays L.*), the staple cereal crop in Malawi and other countries in Sub-Saharan Africa
- Maize grain has inherently low Zn concentrations with median of 21.5 mg kg^{-1} (Botoman et al., 2022a)
- The concentration of Zn in staple cereal grain can be increased through application of Zn-enriched fertilizers, a process called agronomic biofortification or agro-fortification

Objective

To assess the potential of agronomic biofortification by soil application of Zn-enriched fertilizers to increase Zn concentration in the edible part of maize

Materials and methods

- Pre-registered field experiments were conducted at three Agricultural Research Stations using maize variety SC 403 (Botoman et al., 2020)
- At each site two different soil types were used, each corresponding to one of two agriculturally-important soil types of Malawi, Lixisols and Vertisols
- Within each soil type, three Zn fertilizer rates (1, 30 and 90 kg ha^{-1}) using zinc sulphate ($ZnSO_4.7H_2O$) were applied to experimental plots, using soil application method, in a randomized complete block design
- The study had 10 replicates at each of the three experimental sites informed by a power analysis from a pilot study to be able to detect 10% effect (Botoman et al., 2020)
- This is a novel approach to agronomic biofortification studies; typically, studies on maize (and other crops) have limited replication and therefore limited power to detect small effect sizes
- At harvest, Zn concentrations in grain were measured using inductively coupled plasma mass spectrometry (ICP-MS), and Zn uptake by maize grain were calculated

Key findings

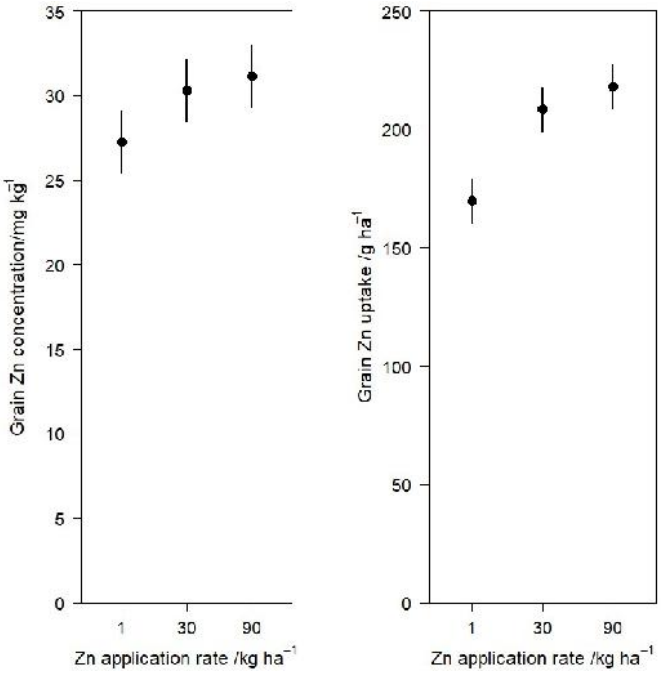

Figure 1. Mean grain Zn concentration and uptake in response to Zn fertilizer application. The error bars show the standard error of the mean (±SEM).

- Grain Zn concentration at 30 kg ha^{-1} Zn application rate was 4 mg kg^{-1} larger than 1 kg ha^{-1} (15% higher than 1 kg ha^{-1})
- Grain Zn concentration did not differ between soil types

- Grain Zn uptake at 30 kg ha^{-1} Zn application rate was 40 g ha^{-1} larger than 1 kg ha^{-1} (23% higher than 1 kg ha^{-1})
- Grain Zn uptake did not differ between soil types

Conclusions

- The results showed that Zn fertilizer application increases the Zn nutritional value of maize grain which can help to meet dietary Zn requirements in humans (Botoman et al., 2022b)
- In the short term, this strategy could be a cost-effective way to alleviate Zn deficiency among the rural populations of developing countries such as Malawi
- The current study provides evidence of the effectiveness and efficiency of agronomic biofortification through application of mineral Zn fertilizers to a range of soils in Malawi
- The results of the study provide a basis for taking evidence-based policy direction in the agricultural sector in Malawi and other countries in addressing human Zn deficiency

References & Contacts

1. Botoman et al., 2020, Plant Direct, 4(10), 1-9
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